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JOINT ARCHITECTURE FOR UNMANNED SYSTEMS (JAUS) TO SOCIETY OF AUTOMOTIVE ENGINEERS (SAE) TRANSITION

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14. ABSTRACT

The Joint Architecture for Unmanned Systems (JAUS) working group has been working on a set of documents in support of interoperability of unmanned systems over the past several years. These documents have reached a level of maturity that they are ready to transition to a commercial standards organization. One of these documents is the Reference Architecture (RA) that specifies a standard set of messages for communicating with unmanned systems. The overall objective of this effort is to complete the transition of the JAUS RA version 3.3 to a Society of Automotive Engineers (SAE) International set of standards.

15. SUBJECT TERMS

Joint Architecture for Unmanned Systems (JAUS), Society of Automotive Engineers (SAE), Reference Architecture (RA), AS-4, AS-4C, robotics, JAUS Service Interface Definition Language (JSIDL), Core Service Set, Mobility Service Set, Mission Spooling Service Set, Environment Sensing Service Set, Manipulator Service Set

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1. OBJECTIVES

The Joint Architecture for Unmanned Systems (JAUS) working group has been working on a set of documents in support of interoperability of unmanned systems over the past several years. These documents have reached a level of maturity that they are ready to transition to a commercial standards organization. One of these documents is the Reference Architecture (RA), which specifies a standard set of messages for communicating with unmanned systems. The overall objective of this effort is to complete the transition of the JAUS RA version 3.3 to a Society of Automotive Engineers (SAE) International set of standards.

2. WORK COMPLETED

The JAUS working group, in cooperation with SAE International, established an unmanned systems committee (AS-4) under SAE's current Aerospace Division. Within this committee, three subcommittees were initially formed:

- AS-4A Architecture Framework,
- AS-4B JAUS Transport, and
- AS-4C Information Modeling and Definition.

One of the responsibilities of AS-4C included the transition of the JAUS Reference Architecture, Part 3, to a set of SAE standards. During this transition, the working group wanted to take advantage of all of the lessons learned from developing and implementing the RA. It was decided to include two major improvements to the standard: to create a formal language to specify interfaces and to include message protocol in the interfaces. These two improvements were aimed at addressing two issues with respect to the current RA interfaces. The RA interfaces were sometimes ambiguous and incomplete, which ultimately led to different interpretations of the specification, and they did not define message ordering. Both of these defects had a direct impact on interoperability and therefore needed to be addressed.

There were two SAE documents already completed prior to beginning this particular effort: JAUS Service Interface Definition Language (JSIDL) and JAUS Core Service Set. The JSIDL document specifies a formal language for defining unambiguous and complete interfaces. This language not only allows for the definition of messages, but it also allows for the definition of the ordering of those messages. The JAUS Core Service Set specifies a set of foundational services, including transport, discovery, events and access control. With JSIDL and the core services in place, the AS-4C subcommittee worked to update the remaining messages in the RA so that they would comply with JSIDL. These messages were first grouped according to the unmanned system capability they addressed and then documented in separate SAE specifications. The following specifications have been created: JAUS Mobility Service Set, JAUS Mission Spooling Service Set, JAUS Environment Sensing Service Set, and JAUS Manipulator Service Set.

The JAUS Mobility Service Set specifies interfaces in a platform independent manner that deal with mobility. It defines a common platform coordinate system along with services for both sensing and controlling platform motion. Twelve services are defined in this document: List Manager, Global Pose Sensor, Local Pose Sensor, Velocity State Sensor, Acceleration State

Sensor, Primitive Driver, Global Vector Driver, Local Vector Driver, Global Waypoint Driver, Local Waypoint Driver, Global Path Segment Driver, and Local Path Segment Driver. These services allow for a range of autonomy, from a teleoperated system to a semi-autonomous waypoint navigation capable system.

The JAUS Mission Spooling Service Set defines platform independent mission execution capabilities. There is a single service defined in this document: Mission Spooler. This service provides a means for a software entity in an unmanned system, or a system of unmanned systems, to communicate and coordinate their activities.

The JAUS Environment Sensing Service Set defines typical environment sensing capabilities commonly found across all domains and types of unmanned systems in a platform-independent manner. These capabilities include providing information from proximity sensors and cameras and controlling their configuration parameters. Five services are defined in this document: Range Sensor, Visual Sensor, Digital Video, Analog Video, and Still Image.

The JAUS Manipulator Service Set specifies interfaces in a platform independent manner that deal with serial manipulator systems. It defines a common coordinate system for serial manipulators along with services for both sensing and controlling their motion. Nine services are defined in this document: Primitive Manipulator Service, Manipulator Joint Position Sensor, Manipulator Joint Velocity Sensor, Manipulator Joint Force/Torque Sensor, Manipulator End-Effector Pose Sensor, Manipulator End-Effector Velocity State Sensor, Manipulator Joint Position Driver, Manipulator Joint Position List Driver, Manipulator End-Effector Pose Driver, Manipulator End-Effector Pose List Driver, Manipulator Joint Velocity Driver, Manipulator End-Effector Velocity State Driver, Manipulator Actuator Force/Torque Driver, Primitive Pan/Tilt, Pan Tilt Joint Position Sensor, Pan Tilt Joint Velocity Sensor, Pan Tilt Position Driver, Pan Tilt Velocity Driver, and Primitive End Effector. These services allow for a range of autonomy with serial manipulators, from a directly teleoperated system to a semi-autonomous capable system.

3. **RESULTS**

The four documents, JAUS Mobility Service Set, JAUS Mission Spooling Service Set, JAUS Environment Sensing Service Set, and JAUS Manipulator Service Set, required to conclude the transition of the JAUS Reference Architecture are complete. Three of these documents have already completed the publication process: JAUS Mobility Service Set, JAUS Environment Sensing Service Set, and JAUS Mission Spooling Service Set, and three are now available for purchase on the SAE website. The remaining document, JAUS Manipulator Service Set, has been balloted by AS-4C subcommittee and will complete the process after the aerospace council ballots the document. Once this is completed, it will also be available for purchase on the SAE website. With the expected publication of all four documents, this effort has exceeded its initial objective of creating initial drafts of each document.

Although this work has completed the transition of the JAUS Reference Architecture to a set of SAE standards, as the capabilities of unmanned systems change and grow these standards will

also need to change and grow. With the foundation of the JSIDL in place, current interfaces can be extended and new interfaces can be introduced to meet this ongoing need.

4. **REFERENCES**

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